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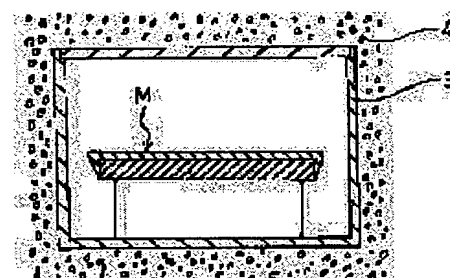
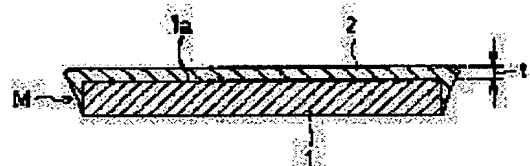
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(54) SINGLE CRYSTAL SILICON CARBIDE AND ITS PRODUCTION

(57)Abstract:

PROBLEM TO BE SOLVED: To stably and efficiently produce a large-sized and high-quality single crystal Si free of occurrence, etc., of crystal nuclei.

SOLUTION: The surface 1a of an α -SiC single crystal substrate 1 is regulated to a surface roughness of $\leq \text{RMS } 2,000 \text{ \AA}$; preferably $\leq \text{RMS } 1,000 \text{ \AA}$; and an α -SiC polycrystal film 2 is then deposited on the surface 1a of the α -SiC single crystal substrate 1 according to a thermal chemical vapor deposition(CVD) method. The resultant composite M is subsequently placed in a porous vessel 3 made of carbon and the outside of the vessel 3 made of the carbon is covered with an α -SiC powder 4 and heat treatment is then carried out at a high temperature of the deposition temperature or above in an argon gas stream. Thereby, an α -SiC single crystal oriented in the same direction as the crystal axis of the α -SiC single crystal substrate 1 is integrally grown by the growth of the crystal and the recrystallization of the α -SiC polycrystal film 2.



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CLAIMS

[Claim(s)]

[Claim 1] The single crystal SiC characterized by forming in the crystallographic axis and this bearing of the above-mentioned alpha-SiC single crystal substrate the alpha-SiC single crystal by which orientation was carried out of recrystallization of crystal growth and the above-mentioned alpha-SiC polycrystal film by heat-treating the complex with which the front face of the alpha-SiC single crystal substrate with which surface roughness was adjusted to 2000A or less of RMS comes to form membranes the alpha-SiC polycrystal film under the elevated temperature beyond membrane formation temperature.

[Claim 2] The single crystal SiC according to claim 1 with which the surface roughness of the above-mentioned alpha-SiC single crystal substrate is adjusted to 1000A or less of RMS.

[Claim 3] The above-mentioned alpha-SiC polycrystal film is the single crystal SiC according to claim 1 or 2 currently formed by thermochemical vacuum deposition.

[Claim 4] The manufacture approach of the single crystal SiC characterized by growing up into one the alpha-SiC single crystal in which orientation was carried out to the crystallographic axis and this bearing of the above-mentioned alpha-SiC single crystal substrate by recrystallization of crystal growth and the above-mentioned alpha-SiC polycrystal film by heat-treating that complex under the elevated temperature beyond membrane formation temperature after adjusting the front face of an alpha-SiC single crystal substrate to 2000 or less RMS surface roughness and forming the alpha-SiC polycrystal film on the front face of this alpha-SiC single crystal substrate.

[Claim 5] The manufacture approach of the single crystal SiC according to claim 4 that the surface roughness of the above-mentioned alpha-SiC single crystal substrate is adjusted to 1000A or less of RMS.

[Claim 6] The manufacture approach of the single crystal SiC according to claim 4 or 5 that the above-mentioned alpha-SiC polycrystal film is formed by thermochemical vacuum deposition.

[Claim 7] Heat treatment of the above-mentioned complex is the manufacture approach of the single crystal SiC according to claim 4 to 6 performed at the temperature of the range of 1900-2400 degrees C where it put this complex into the container made from porosity carbon and the outside of the container made from porosity carbon is covered by alpha-SiC fine particles.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the single crystal SiC used as X-ray optics components, such as a light emitting diode and a monochrome sorter, an elevated-temperature semi-conductor electronic device, a semi-conductor substrate wafer of a power device, etc., and its manufacture approach in detail about a single crystal SiC and its manufacture approach.

[0002]

[Description of the Prior Art] SiC (silicon carbide) is not only excellent in thermal resistance and a mechanical strength, but Since it is strong also in a radiation and valence-electron control of an electron or an electron hole has large forbidden-band width of face an easy top by addition of an impurity further (it is incidentally 3.26eV with about 3.0eV and the SiC single crystal of 4H mold at the SiC single crystal of 6H mold) In the existing semiconductor materials, such as Si (silicon) and GaAs (gallium arsenide), it is possible to realize unrealizable large capacity, high frequency, pressure-proofing, and a resistance to environment, and it is observed as a next-generation semiconductor material for power devices, and is expected.

[0003] By the way, it is what is generally conventionally known as a industrial process of SiC abrasives as the growth (manufacture) approach of this kind of SiC single crystal. Much karyogenesis is started in the core of this seed crystal base material by heating a seed crystal base material with an RF electrode from the periphery of that. The Acheson process which advances two or more curled form crystal growth centering on the center section of the seed crystal base material, and the sublimation recrystallizing method for growing up a crystal on a single crystalline nucleus, using powdery SiC made with the Acheson process as a raw material are learned.

[0004]

[Problem(s) to be Solved by the Invention] However, since a single crystal will grow slowly [long duration], many crystalline nuclei will occur in the phase in early stages of growth not only the rate of crystal growth is very low, but and this will spread even in the upper part of a crystal with crystal growth when based on an Acheson process among the above-mentioned conventional manufacture approaches, it is difficult to obtain a big single crystal independently. Moreover, if it is in the sublimation recrystallizing method, since high-speed growth of 1 mm/hr. extent is mainly adopted by the reason for economical (production cost) A pinhole with a diameter of several microns penetrated in the direction of crystal growth used as causes, such as the leakage current at the time of being called an impurity and a micro pipe defect and producing a semiconductor device, tends to remain during a growth crystal. There is a problem that enough SiC single crystals are not obtained in quality, and though it has the description this excelled [description] in many compared with the existing semiconductor materials, such as Si and GaAs, like previous statement, it is the factor which prevents the utilization.

[0005] This invention was made in view of the above-mentioned actual condition, and is large-sized, and it aims at offering the manufacture approach of the single crystal SiC of the high quality which moreover does not have generating of a crystalline nucleus etc., and the single crystal SiC which can gather the growth rate of this single crystal SiC, and can manufacture a quality single crystal stably and efficiently.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the single crystal SiC

concerning invention according to claim 1 By heat-treating the complex in which the front face of the alpha-SiC single crystal substrate with which surface roughness was adjusted to 2000A or less of RMS comes to form membranes the alpha-SiC polycrystal film under the elevated temperature beyond membrane formation temperature It is what is characterized by forming in the crystallographic axis and this bearing of the above-mentioned alpha-SiC single crystal substrate the alpha-SiC single crystal by which orientation was carried out of recrystallization of crystal growth and the above-mentioned alpha-SiC polycrystal film. Moreover, the manufacture approach of the single crystal SiC concerning invention according to claim 4 After adjusting the front face of an alpha-SiC single crystal substrate to 2000 or less RMS surface roughness and forming the alpha-SiC polycrystal film on the front face of this alpha-SiC single crystal substrate, by heat-treating that complex under the elevated temperature beyond membrane formation temperature It is characterized by growing up into one the alpha-SiC single crystal in which orientation was carried out to the crystallographic axis and this bearing of the above-mentioned alpha-SiC single crystal substrate by recrystallization of crystal growth and the above-mentioned alpha-SiC polycrystal film.

[0007] According to claim 1 which has the above requirements for a configuration, and invention according to claim 4 While using what was adjusted to the surface roughness of 2000A or less of RMS which can cancel easily the mismatching of the crystal lattice by surface physical irregularity being small as an alpha-SiC single crystal substrate, and a phase transformation arising from the base of a crevice, and a side face in coincidence at the time of heat treatment By forming the alpha-SiC polycrystal film on the substrate front face, and heat-treating under the elevated temperature beyond membrane formation temperature Growth of the alpha-SiC single crystal by the side of a substrate is imitated, and the alpha-SiC single crystal by which it recrystallized in the whole region mostly and orientation was carried out to the crystallographic axis and this bearing of an alpha-SiC single crystal substrate excluding [the polycrystalline substance by the side of the above-mentioned alpha-SiC polycrystal film] the edge of the membrane formation part grows up to be one. By this It originates in the mismatching of a crystal lattice, and a crystalline nucleus cannot be generated in an interface, or a micro pipe defect etc. does not occur in it, and the large-sized single crystal SiC can be obtained stably and efficiently with high quality.

[0008] In the manufacture approach of the single crystal SiC concerning the single crystal SiC concerning invention given in above-mentioned claim 1, and invention according to claim 4, it is claim 2 and a thing [adjusting to 1000A or less of RMS like] according to claim 5 being desirable especially desirable, and adjusting the surface roughness of the above-mentioned alpha-SiC single crystal substrate at the surface roughness of 100-500A of RMS. The reason is as follows. Namely, although there is so little generating of a crystalline nucleus that the physical irregularity of the field which forms the alpha-SiC polycrystal film is small and it is desirable If it becomes the coarse field which needs a big effort and time amount for processing it, and exceeds 1000A of RMS until it becomes the surface roughness of less than 100A of RMS It is because a phase transformation arises from the base and side face of a crevice in coincidence at the time of heat treatment, so possibility of canceling the mismatching of a crystal lattice becomes small, and a crystalline nucleus occurs in an interface and it becomes a product of inferior quality.

[0009] Moreover, in the manufacture approach of the single crystal SiC concerning the single crystal SiC concerning invention given in above-mentioned claim 1, and invention according to claim 4, claim 3 and the thing [that membranes are formed by thermochemical vacuum deposition] according to claim 6 of the above-mentioned alpha-SiC polycrystal film are [like] desirable. The reason is as follows. That is, since the membrane formation by thermochemical vacuum deposition can operate equipment under control of a very high precision, it can form homogeneity and the high-definition alpha-SiC polycrystal film, and can carry out alpha-SiC single crystal-ization accompanying heat treatment after membrane formation to still easier and stability by this.

[0010] Furthermore, in invention given in above-mentioned claim 4 thru/or either of 6, it is desirable to perform heat treatment of the above-mentioned complex at the temperature of the range of 1900-2400 degrees C, where [according to claim 7] it put this complex into the container made from porosity carbon and the outside of the container made from porosity carbon is covered by alpha-SiC fine particles like. The reason is as follows. That is, since only the case which only puts into the container made from carbon, and is heat-treated decomposes into Si and C and SiC contained in this container exposes it to the exterior of a

container through the porous container made from carbon, decomposition will be promoted before the phase transformation of SiC. On the other hand, if the outside of the container made from porosity carbon is covered by alpha-SiC fine particles The alpha-SiC fine particles set in the elevated-temperature ambient atmosphere are decomposed, and a part of the decomposed Si and C [at least] import in a container through the container made from porosity carbon. Heat treatment will be performed in a saturation SiC steamy ambient atmosphere, by this, disassembly of the alpha-SiC single crystal by the side of a substrate and the alpha-SiC polycrystal by the side of the polycrystal film can be suppressed, and the quality single crystal SiC can be manufactured certainly.

[0011]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained based on a drawing. the alpha-SiC single crystal substrate of hexagonal system (6H mold, 4H mold) with which drawing 1 - drawing 4 are drawings which explain the manufacture approach of the single crystal SiC concerning this invention in order of a production process, and 1 was processed into disc-like [the disc-like diameter d is about 25mm] in drawing 1 -- it is -- surface 1a of this alpha-SiC single crystal substrate 1 -- grinding -- or polish processing is carried out and physical irregularity is removed. In detail, 2000A or less of RMS, it is 1000A or less of RMS preferably, and the surface 1a is especially adjusted to the surface roughness of the range of 100-500A preferably.

[0012] Then, with the thermochemical vacuum deposition (henceforth a heat CVD method) under conditions as shown in Table 1 at surface 1a of the above-mentioned alpha-SiC single crystal substrate 1, as shown in drawing 2 , the alpha-SiC polycrystal film 2 is formed so that the 200-500 micrometers film thickness t may be preferably set to about 300 micrometers.

[0013]

[Table 1]

(熱CVD条件)

| | キャリア | 炭素源 | シリコン源 |
|-------|---------------------------|-----------------|-------------------|
| 反応ガス | H ₂ | CH ₄ | SiCl ₄ |
| 反応温度 | 1850℃ (1650℃以上) | | |
| 全ガス圧 | 100mbar (30~200mbarが好ましい) | | |
| 全ガス流量 | 50ℓ/min (50ℓ/min以上が好ましい) | | |
| 基板の仕様 | 直径25mmのα-SiC単結晶 | | |
| 成膜速度 | 10μm/hr | | |

[0014] Subsequently, as shown in drawing 3 , the complex M which consists of the above-mentioned alpha-SiC single crystal substrate 1 and alpha-SiC polycrystal film 2 Where it held in the container 3 made from porosity carbon, and it enclosed the outside of this container 3 made from porosity carbon by the alpha-SiC fine particles 4 and it is covered By making it hold for about 2 hours, and heat-treating 1900-2400 degrees C under the temperature of 2200 degrees C, preferably, in an argon air current As shown in drawing 4 Throughout removing the edges 2e and 2e of this alpha-SiC polycrystal film 2 that imitated growth of the single crystal of the above-mentioned alpha-SiC single crystal substrate 1, was made to recrystallize the polycrystalline substance of the above-mentioned alpha-SiC polycrystal film 2, and was continued and formed in the side-face perimeter of the alpha-SiC single crystal substrate 1, the front face of the above-mentioned alpha-SiC single crystal substrate 1 (Crystal orientation side) The alpha-SiC single crystal 5 by which was missing from the above-mentioned alpha-SiC polycrystal film 2 from 1a, and orientation was carried out to the crystallographic axis and this bearing of the alpha-SiC single crystal substrate 1 by one grows.

[0015] 2000A or less of as mentioned above, RMS which can cancel the mismatching of the crystal lattice by surface physical irregularity being small as an alpha-SiC single crystal substrate 1, and a phase transformation arising from the base of a crevice, and a side face in coincidence at the time of heat treatment, What was preferably adjusted to the surface roughness of 1000A or less of RMS is used. By heat-treating the complex M which comes to form membranes the alpha-SiC polycrystal film 2 on the front

face of the substrate 1 under elevated temperature (2200 degrees C, 2 hours) beyond the membrane formation temperature (1850 degrees C) by the heat CVD method Imitate growth of the alpha-SiC single crystal by the side of a substrate 1, and the alpha-SiC single crystal by which it recrystallized in the whole region mostly and orientation was carried out to the crystallographic axis and this bearing of the alpha-SiC single crystal substrate 1 excluding [the polycrystalline substance by the side of the above-mentioned alpha-SiC polycrystal film 2] the edge of the membrane formation part grows up to be one. The crystalline nucleus which originates in the mismatching of a crystal lattice at an interface, and the quality and large-sized single crystal SiC which does not generate a micro pipe defect etc. can be manufactured efficiently. [0016] Incidentally, various surface roughness of the alpha-SiC single crystal substrate 1 was changed, and when the crystallinity by X-ray diffraction was evaluated about each alpha-SiC single crystal manufactured through the above-mentioned production process, the result as shown in Table 2 was obtained. In addition, the numeric value shown in Table 2 is the average when measuring five places of arbitration with the half-value width (integrated-intensity ratio) of the X-ray rocking curve of reflection (0006) of each single crystal.

[0017]

[Table 2]

| 表面粗さ | RMS 3000 Å | 2000 Å | 1000 Å | 500 Å |
|------|------------|--------|--------|-------|
| 半値幅 | 6° | 2° | 0.8° | 0.9° |

[0018] It turns out that half-value width becomes [the surface roughness of the alpha-SiC single crystal substrate 1] narrow rapidly by 2000A of RMS, there is no crystalline dispersion, and the crystal has become the good thing of unity so that clearly also from the above-mentioned table 2.

[0019] Furthermore, by putting this complex M into the container 3 made from porosity carbon, and covering the outside of the container 3 made from carbon by the alpha-SiC fine particles 4 in heat treatment of the above-mentioned complex M, and performing predetermined heat treatment in an argon air current The alpha-SiC fine particles 4 are decomposed in an elevated-temperature ambient atmosphere, a part of the decomposed Si and C [at least] are made to import in this container 3 through the porous container 3 made from carbon, and heat treatment predetermined in the inside of a saturation SiC steamy ambient atmosphere can be performed. By this While it is possible to suppress disassembly of the alpha-SiC single crystal substrate 1 and the alpha-SiC polycrystal film 2, and to manufacture the more quality single crystal SiC It is possible it to also be prevented for that Si imported in a container 3 through the porous container 3 made from carbon and C adhere to SiC before a phase transformation, and to excel in quality further and to manufacture the beautiful single crystal SiC by this.

[0020]

[Effect of the Invention] As mentioned above, according to claim 1 and invention according to claim 4 That of the alpha-SiC single crystal substrate adjusted to the surface roughness of 2000A or less of RMS which can cancel easily the mismatching of the crystal lattice by surface physical irregularity being small and a phase transformation arising from the base of a crevice and a side face in coincidence at the time of heat treatment is used. By forming the alpha-SiC polycrystal film on this substrate front face, and heat-treating under the elevated temperature beyond membrane formation temperature The alpha-SiC single crystal in which orientation was carried out to the crystallographic axis and this bearing of an alpha-SiC single crystal substrate by the recrystallization [in / almost / the whole region] except the edge of the polycrystalline substance by the side of the alpha-SiC polycrystal film which imitates growth of the alpha-SiC single crystal by the side of a substrate can be grown up into one. Therefore, the large-sized single crystal SiC which originates in the mismatching of a crystal lattice, does not generate a crystalline nucleus in an interface or does not generate a micro pipe defect etc. in it can be obtained stably and efficiently with high quality. The effectiveness that utilization of the single crystal SiC which is excellent in large capacity, high frequency, pressure-proofing, and a resistance to environment compared with the existing semiconductor materials, such as Si (silicon) and As (gallium arsenide), and is expected as a semiconductor material for power devices by this can be promoted is done so.

[0021] Especially, according to claim 2 and invention according to claim 5, the dissolution degree of the

mismatching of a crystal lattice is high, and the single crystal SiC of the μ c-layer high quality which the crystalline nucleus etc. has not generated in an interface can be obtained.

[0022] Moreover, according to claim 3 and invention according to claim 6, it is possible to form the alpha-SiC polycrystal film to homogeneity and high definition on the front face of an alpha-SiC single crystal substrate, and alpha-SiC single crystal-ization accompanying heat treatment after membrane formation can be carried out to still easier and stability.

[0023] Furthermore, according to invention according to claim 7, it can also be prevented that Si which could perform predetermined heat treatment in the saturation SiC steamy ambient atmosphere, and could prevent degradation of the quality by disassembly of an alpha-SiC single crystal substrate and the alpha-SiC polycrystal film, and was decomposed, and C adhere to SiC before a phase transformation, and the beautiful single crystal SiC can be manufactured with high quality by this.

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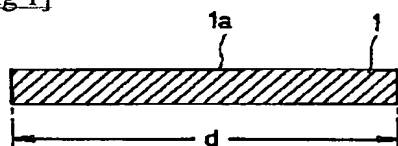
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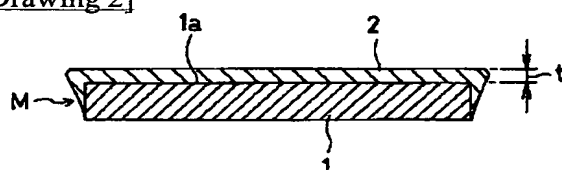
DRAWINGS

[Drawing 1]



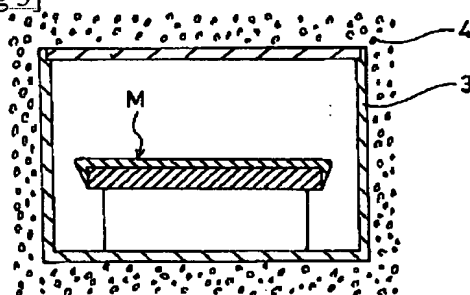
1 : α -SiC単結晶基板
1 a : 表面 (RMS2000Å以下)

[Drawing 2]



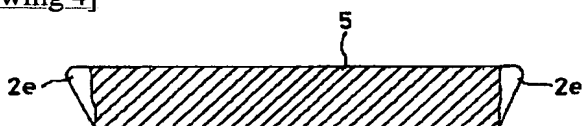
2 : α -SiC多結晶膜

[Drawing 3]



3 : 多孔質カーボン製容器
4 : α -SiC粉体

[Drawing 4]



5 : 単結晶 SiC

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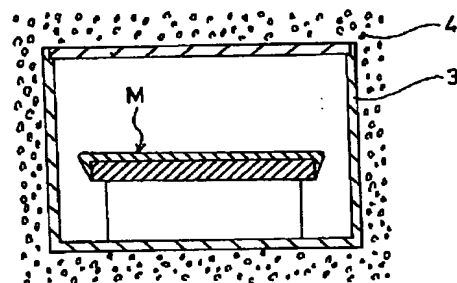
(74) 代理人 弁理士 鈴江 孝一 (外1名)

(54) 【発明の名称】 単結晶SiC及びその製造方法

(57) 【要約】

【課題】 大型で、しかも結晶核の発生などがない高品質の単結晶SiCを安定に、かつ、効率よく製造することができるようにする。

【解決手段】 α -SiC単結晶基板1の表面1aをRMS2000オングストローム以下、好ましくはRMS1000オングストローム以下の表面粗さに調整し、この α -SiC単結晶基板1の表面1aに熱CVD法により α -SiC多結晶膜2を成膜した後、その複合体Mを多孔質カーボン製容器3に入れ、かつ、そのカーボン製容器3の外側を α -SiC粉体4により覆ってアルゴン気流中で成膜温度以上の高温下で熱処理することにより、結晶の成長と α -SiC多結晶膜2の再結晶化によって α -SiC単結晶基板1の結晶軸と同方位に配向された α -SiC単結晶を一体に成長させる。



3 : 多孔質カーボン製容器

4 : α -SiC粉体

【特許請求の範囲】

【請求項1】 表面粗さがRMS2000オングストローム以下に調整された α -SiC単結晶基板の表面に α -SiC多結晶膜が成膜されてなる複合体を成膜温度以上の高温下で熱処理することにより、結晶の成長と上記 α -SiC多結晶膜の再結晶化とによって上記 α -SiC単結晶基板の結晶軸と同方位に配向された α -SiC単結晶が形成されていることを特徴とする単結晶SiC。

【請求項2】 上記 α -SiC単結晶基板の表面粗さがRMS1000オングストローム以下に調整されている請求項1に記載の単結晶SiC。

【請求項3】 上記 α -SiC多結晶膜は熱化学的蒸着法によって成膜されている請求項1または2に記載の単結晶SiC。

【請求項4】 α -SiC単結晶基板の表面をRMS2000以下の表面粗さに調整し、この α -SiC単結晶基板の表面に α -SiC多結晶膜を成膜した後、その複合体を成膜温度以上の高温下で熱処理することにより、結晶の成長と上記 α -SiC多結晶膜の再結晶化とによって上記 α -SiC単結晶基板の結晶軸と同方位に配向された α -SiC単結晶を一体に成長させることを特徴とする単結晶SiCの製造方法。

【請求項5】 上記 α -SiC単結晶基板の表面粗さがRMS1000オングストローム以下に調整されている請求項4に記載の単結晶SiCの製造方法。

【請求項6】 上記 α -SiC多結晶膜が熱化学的蒸着法によって成膜される請求項4または5に記載の単結晶SiCの製造方法。

【請求項7】 上記複合体の熱処理は、該複合体を多孔質カーボン製容器に入れ、かつ、その多孔質カーボン製容器の外側を α -SiC粉体により覆った状態で1900~2400℃の範囲の温度で行なわれる請求項4ないし6のいずれかに記載の単結晶SiCの製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、単結晶SiCおよびその製造方法に関するもので、詳しくは、発光ダイオードやモノクロソーターなどのX線光学素子、高温半導体電子素子やパワーデバイスの半導体基板ウエハなどとして用いられる単結晶SiCおよびその製造方法に関するものである。

【0002】

【従来の技術】SiC（炭化珪素）は、耐熱性および機械的強度に優れているだけでなく、放射線にも強く、さらに不純物の添加によって電子や正孔の価電子制御が容易である上、広い禁制帯幅を持つ（因みに、6H型のSiC単結晶で約3.0eV、4H型のSiC単結晶で3.26eV）ために、Si（シリコン）やGaAs

（ガリウムヒ素）など既存の半導体材料では実現することができない大容量、高周波、耐圧、耐環境性を実現することが可能で、次世代のパワーデバイス用半導体材料として注目され、かつ期待されている。

【0003】ところで、この種のSiC単結晶の成長（製造）方法として、従来、SiC研磨材の工業的製法として一般的に知られているもので、種結晶基材をその外周から高周波電極で加熱することにより該種結晶基材の中心部で多くの核発生を起こして、種結晶基材の中央部を中心として複数の渦巻き状の結晶成長を進行させるアチソン法や、アチソン法で作られた粉状のSiCを原料として用い、単一の結晶核上に結晶を成長させる昇華再結晶法とが知られている。

【0004】

【発明が解決しようとする課題】しかしながら、上記した従来の製造方法のうちアチソン法による場合は長時間に亘ってゆっくりと単結晶が成長するもので結晶成長速度が非常に低いだけでなく、成長初期の段階で多数の結晶核が発生してこれが結晶成長とともに結晶の上部にまで伝播されることになるため、単独で大きな単結晶を得ることが困難である。また、昇華再結晶法にあっては、主として経済的（生産コスト）理由によって1mm/h程度の高速成長が採用されるために、不純物およびマイクロパイプ欠陥と呼ばれ半導体デバイスを作製した際の漏れ電流等の原因となる結晶の成長方向に貫通する直径数ミクロンのピンホールが成長結晶中に残存しやすく、品質的に十分なSiC単結晶が得られないという問題があり、このことが既述のようにSiやGaAsなどの既存の半導体材料に比べて多くの優れた特徴を有しながらも、その実用化を阻止する要因になっている。

【0005】本発明は上記実情に鑑みてなされたもので、大型で、しかも結晶核の発生などが無い高品質の単結晶SiCと、この単結晶SiCの成長速度を上げて高品質な単結晶を安定に、かつ、効率よく製造することができる単結晶SiCの製造方法を提供することを目的としている。

【0006】

【課題を解決するための手段】上記目的を達成するために、請求項1に記載の発明に係る単結晶SiCは、表面粗さがRMS2000オングストローム以下に調整された α -SiC単結晶基板の表面に α -SiC多結晶膜が成膜されてなる複合体を成膜温度以上の高温下で熱処理することにより、結晶の成長と上記 α -SiC多結晶膜の再結晶化とによって上記 α -SiC単結晶基板の結晶軸と同方位に配向された α -SiC単結晶が形成されていることを特徴とするものであり、また、請求項4に記載の発明に係る単結晶SiCの製造方法は、 α -SiC単結晶基板の表面をRMS2000以下の表面粗さに調整し、この α -SiC単結晶基板の表面に α -SiC多結晶膜を成膜した後、その複合体を成膜温度以上の高温

下で熱処理することにより、結晶の成長と上記 α -SiC多結晶膜の再結晶化とによって上記 α -SiC単結晶基板の結晶軸と同方位に配向された α -SiC単結晶を一体に成長させることを特徴とするものである。

【0007】上記のような構成要件を有する請求項1及び請求項4に記載の発明によれば、 α -SiC単結晶基板として、表面の物理的な凹凸が小さく熱処理時に凹部の底面と側面とから同時に相変態が生じることによる結晶格子の不整合を容易に解消することが可能なRMS2000オングストローム以下の表面粗さに調整されたものを用いるとともに、その基板表面に α -SiC多結晶膜を成膜して成膜温度以上の高温下で熱処理することによって、基板側の α -SiC単結晶の成長に倣い上記 α -SiC多結晶膜側の多結晶体がその成膜部分の端部を除くほぼ全域において再結晶化されて α -SiC単結晶基板の結晶軸と同方位に配向された α -SiC単結晶が一体に成長し、これによって、結晶格子の不整合に起因して界面に結晶核を発生したり、マイクロバンプ欠陥などが発生したりすることがなく、高品質で、かつ、大型の単結晶SiCを安定かつ効率よく得ることができる。

【0008】上記請求項1に記載の発明に係る単結晶SiC及び請求項4に記載の発明に係る単結晶SiCの製造方法において、上記 α -SiC単結晶基板の表面粗さを、請求項2および請求項5に記載のように、RMS1000オングストローム以下に調整することが望ましく、特に好ましくは、RMS100～500オングストロームの表面粗さに調整されていることである。その理由は次のとおりである。即ち、 α -SiC多結晶膜を成膜する面の物理的な凹凸は小さいほど結晶核の発生が少なく好ましいが、RMS100オングストローム未満の表面粗さになるまで加工するには大きな労力と時間を必要とし、またRMS1000オングストロームを越える粗い面になると、熱処理時に凹部の底面と側面から同時に相変態が生じるために、結晶格子の不整合を解消する可能性が小さくなって、界面に結晶核が発生し品質の悪い製品になってしまうからである。

【0009】また、上記請求項1に記載の発明に係る単結晶SiC及び請求項4に記載の発明に係る単結晶SiCの製造方法において、上記 α -SiC多結晶膜は、請求項3および請求項6に記載のように、熱化学的蒸着法によって成膜されていることが望ましい。その理由は次のとおりである。即ち、熱化学的蒸着法による成膜は極めて高い精度の制御下で装置を運転することが可能であ

るために、均質かつ高品質の α -SiC多結晶膜を成膜することができ、これによって、成膜後の熱処理に伴う α -SiC単結晶化を一層容易かつ安定に行なうことができる。

【0010】さらに、上記請求項4ないし6のいずれかに記載の発明において、上記複合体の熱処理は、請求項7に記載のように、該複合体を多孔質カーボン製容器に入れ、かつ、その多孔質カーボン製容器の外側を α -SiC粉体により覆った状態で1900～2400℃の範囲の温度で行なうことが好ましい。その理由は次のとおりである。即ち、単にカーボン製容器に入れて熱処理するだけの場合は、該容器内に収納されているSiCがSiとCに分解し、ポーラスなカーボン製容器を通じて容器の外側に露出するために、SiCの相変態以前に分解が促進されてしまう。これに対して、多孔質カーボン製容器の外側を α -SiC粉体により覆っておけば、高温雰囲気におかれている α -SiC粉体が分解され、その分解されたSi、Cの少なくとも一部が多孔質カーボン製容器を通じて容器内に移入して、飽和SiC蒸気雰囲気の中で熱処理が行われることになり、これによって、基板側の α -SiC単結晶および多結晶膜側の α -SiC多結晶の分解を抑えて品質の良い単結晶SiCを確実に製造することができる。

【0011】

【発明の実施の形態】以下、本発明の実施の形態を図面にもとづいて説明する。図1～図4は本発明に係る単結晶SiCの製造方法を製造工程順に説明する図であり、図1において、1は直径dが25mm程度の円板状に加工された六方晶系（6H型、4H型）の α -SiC単結晶基板であり、この α -SiC単結晶基板1の表面1aを研削または研磨加工して物理的な凹凸を除去する。詳しくは、その表面1aをRMS2000オングストローム以下、好ましくはRMS1000オングストローム以下で、特に好ましくは100～500オングストロームの範囲の表面粗さに調整する。

【0012】その後、上記 α -SiC単結晶基板1の表面1aに、表1に示すような条件下での熱化学的蒸着法（以下、熱CVD法という）により、図2に示すように、 α -SiC多結晶膜2を、その膜厚sが200～500 μ m、好ましくは300 μ m程度になるように成膜する。

【0013】

【表1】

(熱CVD条件)

| 反応ガス | キャリア | 炭素源 | シリコン源 |
|-------|---------------------------|-----------------|---------------------------------|
| | H ₂ | CH ₄ | SiC ₂ H ₄ |
| 反応温度 | 1850℃ (1650℃以上) | | |
| 全ガス圧 | 100mbar (30~200mbarが好ましい) | | |
| 全ガス流量 | 50ℓ/min (50ℓ/min以上が好ましい) | | |
| 基板の仕様 | 直径25mmのα-SiC単結晶 | | |
| 成膜速度 | 10μm/hr | | |

【0014】次いで、上記α-SiC単結晶基板1とα-SiC多結晶膜2とからなる複合体Mを図3に示すように、多孔質カーボン製容器3に収容し、かつ、この多孔質カーボン製容器3の外側をα-SiC粉体4により囲い覆った状態で、アルゴン気流中において1900~2400℃、好ましくは2200℃の温度下に2時間程度保持させて熱処理することにより、図4に示すように、上記α-SiC単結晶基板1の単結晶の成長に倣って上記α-SiC多結晶膜2の多結晶体を再結晶させてα-SiC単結晶基板1の側面全周に亘って形成された該α-SiC多結晶膜2の端部2e、2eを除く全域に上記α-SiC単結晶基板1の表面(結晶方位面)1aから上記α-SiC多結晶膜2にかけて一体で、α-SiC単結晶基板1の結晶軸と同方位に配向されたα-SiC単結晶5が成長される。

【0015】上記のように、α-SiC単結晶基板1として、表面の物理的な凹凸が小さく熱処理時に凹部の底面と側面とから同時に相変態が生じることによる結晶格子の不整合を解消することが可能なRMS2000オングストローム以下、好ましくはRMS1000オングストローム以下の表面粗さに調整されたものを用い、その

基板1の表面にα-SiC多結晶膜2を成膜してなる複合体Mを熱CVD法による成膜温度(1850℃)以上の高温(2200℃、2時間)下で熱処理することによって、基板1側のα-SiC単結晶の成長に倣い上記α-SiC多結晶膜2側の多結晶体がその成膜部分の端部を除くほぼ全域において再結晶化されてα-SiC単結晶基板1の結晶軸と同方位に配向されたα-SiC単結晶が一体に成長して、界面に結晶格子の不整合に起因する結晶核や、マイクロパイプ欠陥などを発生することのない高品質で、かつ、大型の単結晶SiCを効率よく製造することができる。

【0016】因みに、α-SiC単結晶基板1の表面粗さを種々変化させ、上記の製造工程を経て製造されるα-SiC単結晶それぞれについてX線回折による結晶性を評価したところ表2のような結果が得られた。なお、表2に示す数値は、各単結晶の(0006)反射のX線ロックアップカーブの半値幅(積分強度比)で任意の5箇所を計測したときの平均値である。

【0017】

【表2】

| 表面粗さ | RMS3000Å | 2000Å | 1000Å | 500Å |
|------|----------|-------|-------|------|
| 半値幅 | 6° | 2° | 0.8° | 0.9° |

【0018】上記の表2からも明らかなように、α-SiC単結晶基板1の表面粗さがRMS2000オングストロームで半値幅が急激に狭くなり、結晶性のばらつきがなくて、結晶が単一性の良好なものになっていることが分かる。

【0019】さらに、上記複合体Mの熱処理にあたって、該複合体Mを多孔質カーボン製容器3に入れ、かつ、そのカーボン製容器3の外側をα-SiC粉体4により覆ってアルゴン気流中で所定の熱処理を行なうことによって、高温雰囲気中でα-SiC粉体4が分解され、その分解されたSi、Cの少なくとも一部をポーラスなカーボン製容器3を通じて該容器3内に移入させて飽和SiC蒸気雰囲気の中で所定の熱処理を行なえ、これによって、α-SiC単結晶基板1およびα-SiC多結

晶膜2の分解を抑えてより品質の良い単結晶SiCを製造することが可能であるとともに、ポーラスなカーボン製容器3を通じて容器3内に移入されるSi、Cが相変態前にSiCに付着することも防止でき、これによって、一層品質に優れ、かつ美麗な単結晶SiCを製造することが可能である。

【0020】

【発明の効果】以上のように、請求項1および請求項4に記載の発明によれば、表面の物理的な凹凸が小さく熱処理時に凹部の底面と側面とから同時に相変態が生じることによる結晶格子の不整合を容易に解消することが可能なRMS2000オングストローム以下の表面粗さに調整されたα-SiC単結晶基板とものを用い、この基板表面にα-SiC多結晶膜を成膜して成膜温度以上の

高温下で熱処理することにより、基板側の α -SiC単結晶の成長に倣う α -SiC多結晶膜側の多結晶体の端部を除くほぼ全域における再結晶化によって α -SiC単結晶基板の結晶軸と同方位に配向された α -SiC単結晶を一体に成長させることができる。したがって、結晶格子の不整合に起因して界面に結晶核を発生したり、マイクロパイプ欠陥などを発生したりすることのない高品質で、かつ、大型の単結晶SiCを安定に、かつ効率よく得ることができる。これによって、Si（シリコン）やAs（ガリウムヒ素）などの既存の半導体材料に比べて大容量、高周波、耐圧、耐環境性に優れパワーデバイス用半導体材料として期待されている単結晶SiCの実用化を促進することができるという効果を奏する。

【0021】特に、請求項2および請求項5に記載の発明によれば、結晶格子の不整合の解消度合が高く、界面に結晶核などが発生していない一層高品質の単結晶SiCを得ることができる。

【0022】また、請求項3および請求項6に記載の発明によれば、 α -SiC単結晶基板の表面に α -SiC多結晶膜を均質かつ高品位に成膜することが可能で、成膜後の熱処理に伴う α -SiC単結晶化を一層容易かつ安定に行なうことができる。

【0023】さらに、請求項7に記載の発明によれば、

所定の熱処理を飽和SiC蒸気雰囲気の中で行なえて、 α -SiC単結晶基板および α -SiC多結晶膜の分解による品質の劣化を防止することができ、また、分解したSi、Cが相変態前にSiCに付着することも防止でき、これによって、より高品質で、かつ美麗な単結晶SiCを製造することができる。

【図面の簡単な説明】

【図1】本発明に係る単結晶SiCの製造方法のうち α -SiC単結晶基板を示す側面図である。

【図2】同上 α -SiC単結晶基板の表面に熱CVD法により α -SiC多結晶膜を成膜した状態を示す側面図である。

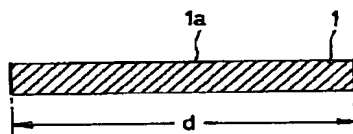
【図3】複合体の熱処理状況を示す概略側面図である。

【図4】同上熱処理により得られた単結晶SiCを示す正面図である。

【符号の説明】

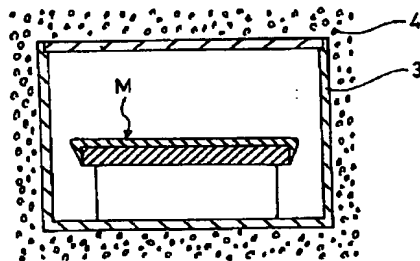
- 1 α -SiC単結晶基板
- 1a 表面
- 2 α -SiC多結晶膜
- 3 多孔質カーボン製容器
- 4 α -SiC粉体
- 5 単結晶SiC
- M 複合体

【図1】



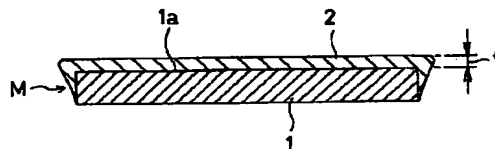
1 : α -SiC単結晶基板
1a : 表面 (RMS2000Å以下)

【図3】



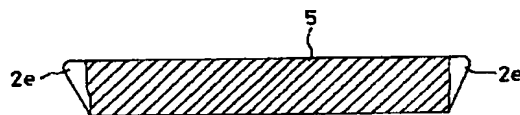
3 : 多孔質カーボン製容器
4 : α -SiC粉体

【図2】



2 : α -SiC多結晶膜

【図4】



5 : 単結晶 SiC

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